THE HYDRAULIC AND STRUCTURAL DESIGN OF LARGE SEWERS

BY

HJALMAR ST. PIERRE SUNDIN

B.S., Dartmouth College, 1946
M.C.E., Rensselaer Polytechnic Institute, 1947
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AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENGINEERING
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Present methods for the hydraulic and structural design of large sewer sections are investigated in an attempt to obtain more exact and reliable methods of analysis.

Starting with the von Karman-Nikuradse (1) laws of turbulent flow in circular pipes flowing full, expressions are derived for rectangular and triangular channels and for circular pipes flowing partly full. In the course of the studies the variation of boundary shear in channels of the above shapes was determined and was found to be significant only in retangular channels. Equations are presented which express the variation mathematically. All equations were checked against velocity measurements made by Bazin (2) and in general the correlation between computed and observed results is satisfactory.

The derived mean velocity expressions are compared with the Manning equation. This leads to theoretical expressions for the variation of Manning's n in rectangular and triangular channels and in circular sewers flowing partially full. Nomographs are presented to simplify the calculations. There are few reliable experimental studies of the variation of n with depth of flow in circular pipes. What data are available tend to confirm the relationships derived.

The Manning and Kutter equations were found to produce nearly identical results within the ranges studied. Since the accuracy of each is dependent on the use of the proper value of n, the Manning equation is just as reliable as the Kutter, and is to be recommended because of its simplicity.

The structural analysis of sewer sections can be no more precise than the knowledge of loading conditions and the elastic properties of the material of which the sections are constructed. This is no reason to tolerate serious inaccuracies which enter into the structural analysis due to the method of

calculation in common use. The possible sources of inaccuracy in the neutral point method and the column analogy method were studied in order, and were found to be of relatively minor significance except for the procedure of calculating static moments from a series of substituted point loads. Whereas this calculation procedure produces reasonably satisfactory results in arches of small rise, it was found that it introduced major inaccuracies when applied to sewer arches, in which the rise is often greater than the span. If the static moments are calculated directly from the distributed loading, the accuracy of the results is improved while at the same time the labor of calculation can be reduced by cutting the section into only one-half or one-quarter as many voussoirs. The accuracy of analysis of long span arches can also be improved by computing static moments directly from the distributed loading rather than from the series of point loads.

The effect of curvature was investigated to determine whether the small radius of curvature encountered in sewer arches is important. It was concluded that curvature has an important effect on stress distribution and maximum fiber stresses, but has little influence on the moment of inertia of the section.

BIBLIOGRAPHY

1. Bakhmeteff, B. A., *The Mechanics of Turbulent Flow*, Princeton University Press, (1936).

2. Bazin, H., *Recherches Hydrauliques*, Paris, (1865).

VITA

Hjalmar St. Pierre Sundin was born on April 2, 1926 in Jamestown, New York. After graduating from Jamestown High School in 1943, he entered the Navy V-12 program at Rensselaer Polytechnic Institute in Troy, New York. He was transferred to the Thayer School of Engineering at Dartmouth College and received the degree of Bachelor of Science, with highest honors from that institution in February, 1946. Following a short period of service with the Navy in the Atlantic he returned to Rensselaer Polytechnic Institute on a graduate fellowship and received the degree of Master of Civil Engineering in June, 1947. In October of the same year he entered the Graduate College of the University of Illinois. He received his Master of Science Degree in June, 1949, and held an Assistantship in Civil Engineering for the academic years 1948-49 and 1949-50, and an Instructorship from September, 1950 until February, 1952. He was elected to Phi Beta Kappa at Dartmouth and to the Society of Sigma Xi at Rensselaer Polytechnic Institute.